GE Nuclear Energy

Requests for Additional Information - PANDA RAIs

ESBWR NRC Meeting
Closed Session
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Rockville, Maryland

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Topics to be Covered

Brief Overview of Test Series

TRACG Model of PANDA

General TRACG Questions

Test Specific Questions

Questions on Summary/Conclusions

Summary

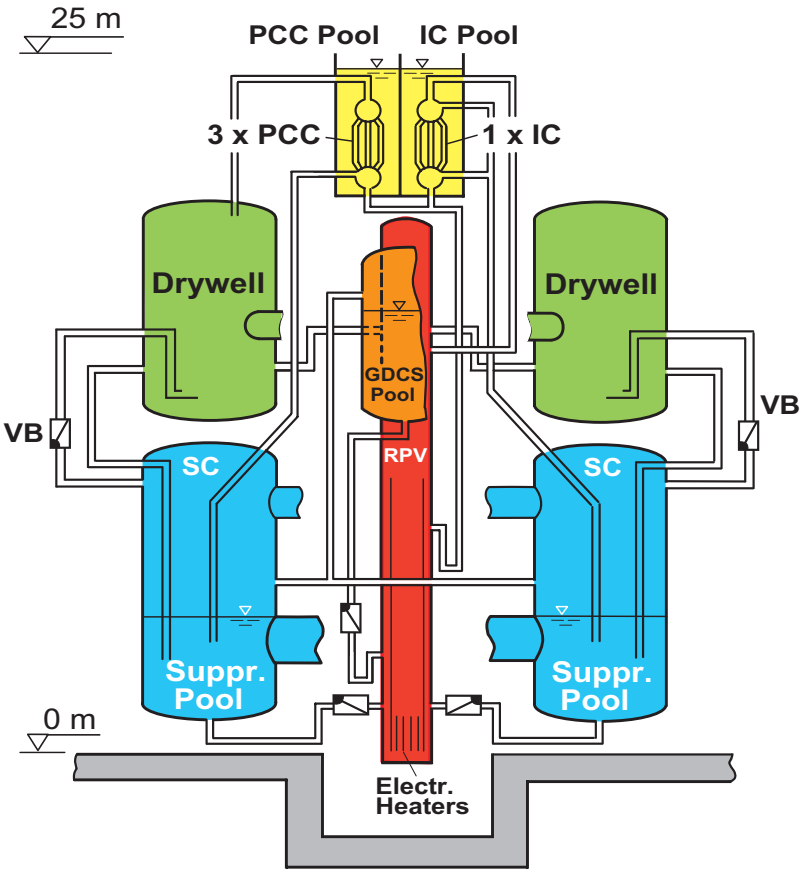
PANDA Facility

1:45 power/volume scaled ESBWR

Represented in facility:

- Reactor Pressure Vessel (RPV) - single vessel
- Gravity Driven Cooling System (GDCS) - single vessel
- Wetwell (WW) - two vessels connected by single pipe
- Drywell (DW) - two vessels connected by two pipes
- Passive Cooling System Condensers (PCCS) - three condensers
- Isolation Condenser (IC) - one condenser
- Connecting Valves and Piping

PANDA Schematic



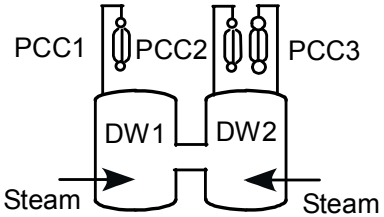
PANDA

Scaling:

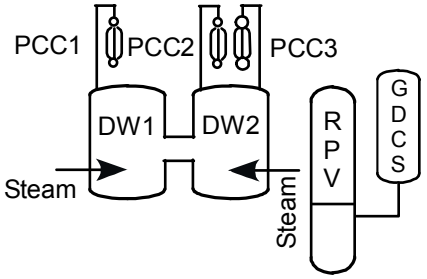
Height ~ 1 : 1
Volume ~ 1 : 40
Power ~ 1 : 40

PANDA - P Series (TEPPS) Test Matrix

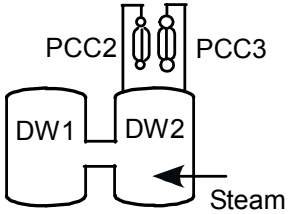
P1: Base Case
MSL Break + 1 hr
(long-term cooling phase)



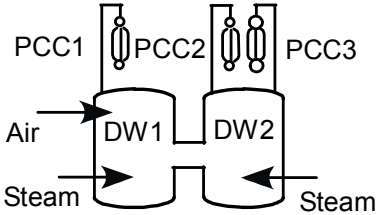
P2: Early Start
MSL Break + 20 min
(transition from GDCS injection to long-term PCCS cooling phase)



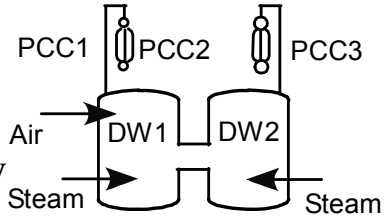
P3: PCCS Start-up
DW initially filled with air
(deomonstrate PCCS start-up Under challenging conditions)
RPV power constant.



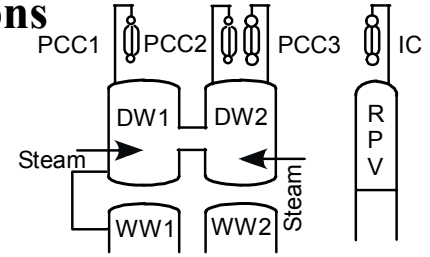
P4: Trapped Air in DW
Air released during transient
(investigation of how n/c gas Affects PCCS performance)



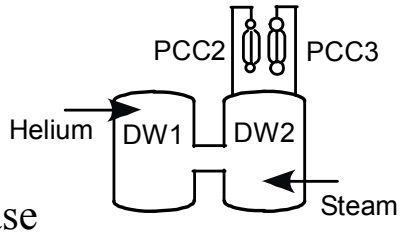
P5: Symmetric Case
PCC2 Isolated, air supply to DW later in transient
(MV clearing phase caused by Reduced PCC capacity)



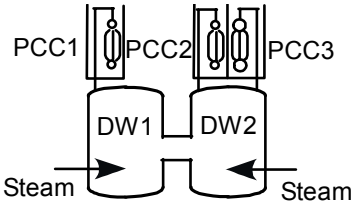
P6: Systems Interactions
ICs and PCCs in parallel,
DW1 to WW1 leakage
(is PCC performance adverseley affected?)



P7: Severe Accident
All break flow to DW2,
PCC1 isolated, He supply to DW later in transient
(simulation of hydrogen release & reduced PCC capacity)



P8: PCC Pool Boil Down
Extension of Base Case, P1
(how do PCC pool levels affect containment performance)



TRACG Model of PANDA

- TRACG VSSL Component used to model vessels in facility w/PIPE & VLVE connections (20 levels, 2 rings, 4 sectors)
- Similar to the ESBWR model, but represents specific geometric features of PANDA
- Line losses and system heat losses based on facility characterization tests
- Some changes from model used for M-Series
  - » PCC/IC pools and RPV included in VSSL component
  - » DW connected by two pipes
  - » One less level in WW, DW and GDCS vessels
- PCC heat transfer uses special correlation from component tests

General TRACG Questions

- PANDA/ESBWR Nodalization differences
- Pre-test calculations
- Time step selection
- System pressure response at start of test and PCCS operation
- DW-WW pressure difference predictions
- Editorial – variable definitions and problem with MTG.D1.2 in Table 2

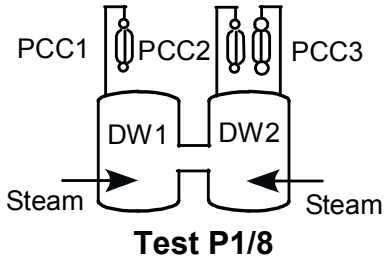
TRACG Nodalization of PANDA

TRACG Nodalization of the ESBWR

Test P4 DW/WW Pressures

Test P4 TRACG DW/WW Pressures

Test Specific Questions



Test P1/8

System Response to VB openings and PCCS operation

System energy balance

PCCS operation at zero WW-DW pressure difference

WW-to DW pressure difference predictions

PCC pool level

Problems with WW gas and liquid temperature predictions

Test P1/8 DW/WW Pressures

Test P1/8 DW/WW Pressure Difference

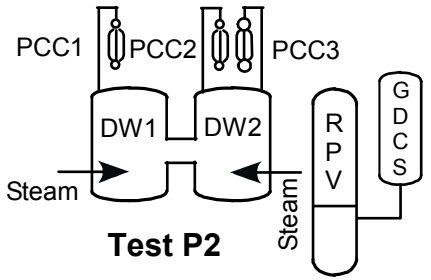
Test P1/8 Heater Power & PCC Heat Removal

Test P1/8 PCC Pool Levels

Test P1/8 WW1 Gas Temperatures

Test P1/8 WW1 Pool Temperatures

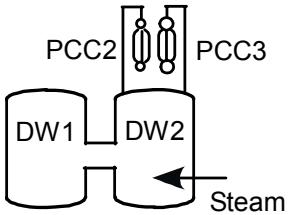
Test Specific Questions (Cont.)



Test P2

Test P2

- Effect of Leaky Check Valve
- Initial system pressure response comparisons
- Steady PCCS flow with declining DW-WW press difference
- GDCS/RPV vessel level after 1200s
- WW water temperature comparisons
- WW air partial pressure comparisons



Test P3

Test P3

- DW air purging

Test P2 DW/WW Pressures

Test P2 DW/WW Pressure Difference

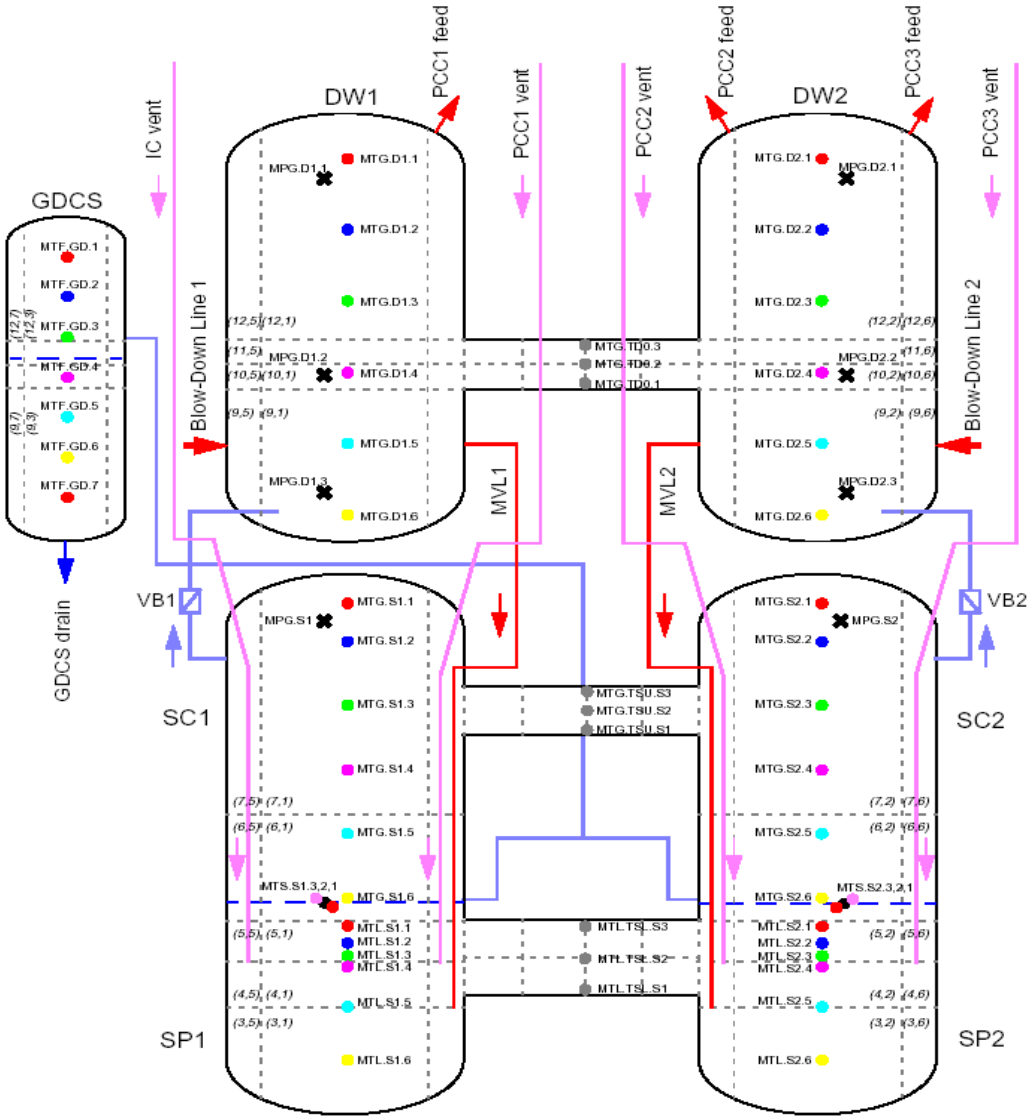
Test P2 PCC Flows

Test P2 RPV & GDSC Collapsed Levels

Test P2 WW1 Pool Temperatures

Test P2 DW1 Air Partial Pressure

PANDA Instrumentation

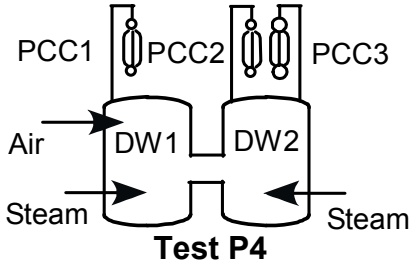


Test P3 DW/WW Pressures

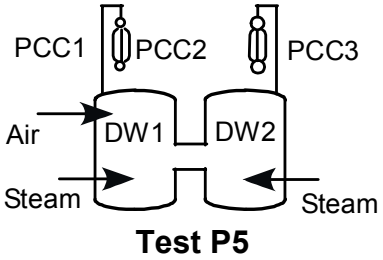
Test P3 DW1 Air Partial Pressure

Test P3 DW2 Air Partial Pressure

Test Specific Questions (Cont.)



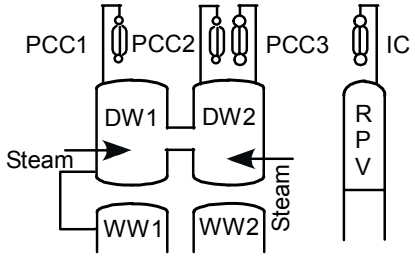
Test P4



Test P5

Test P4&5

Would not a slow release (order of 1% or less) of noncondensibles be a better test of delayed release ?



Test P6

Test P6

Why combine IC operation and steam bypass

Why does WW-DW press diff decrease slower than in P1/8

Why do the PCCs still work when WW-DW $\Delta p = 0$

Press diff blip at 42,000 s

Over-prediction of VB flow between 15,000-25,000s

Test P4 DW/WW Pressures

Test P4 Heater Power & PCC Heat Removal

Test P6 DW/WW Pressures

Test P6 DW/WW Pressure Difference

Test P6 VB Leakage Flow

Summary/Conclusions Questions

- PCC tube gas temperature comparisons
- Uncertainty in pool-side heat transfer
- WW gas temperature and effect of steam partial pressure on overall system pressure.

- Other

  Are the 560 instruments in PANDAS sufficient to provide reliable (w/built-in redundancy and cross-checking) mass and energy balance ? (Q272)

  Which PANDA tests have main vent openings ? (Q296)

  In Test P6, why was IC valved out after 6 hours, why not one hour ? (Q297)

Test P/8 Main Vent Line 1 Phase Indicator

PANDA Questions Summary

- PANDA Tests have demonstrated the robustness of the passive heat removal system operation over a wide range of conditions.

- The TRACG predictions of PANDA capture the global system response and operation of the passive heat removal systems.

- TRACG is expected to successfully predict the passive system operation and the overall behavior of the ESBWR.